RESEARCH DEPARTMENT

U.H.F. harmonic radiation from V.H.F. tuners in television receivers

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'U.H.F. Harmonic Radiation from V.H.F. Tuners in Television Receivers'

Page 8 last paragraph - change 5·75 Mc/s to +5·5 Mc/s.

Page 9 incorporate modified Fig. 8 as shown below.

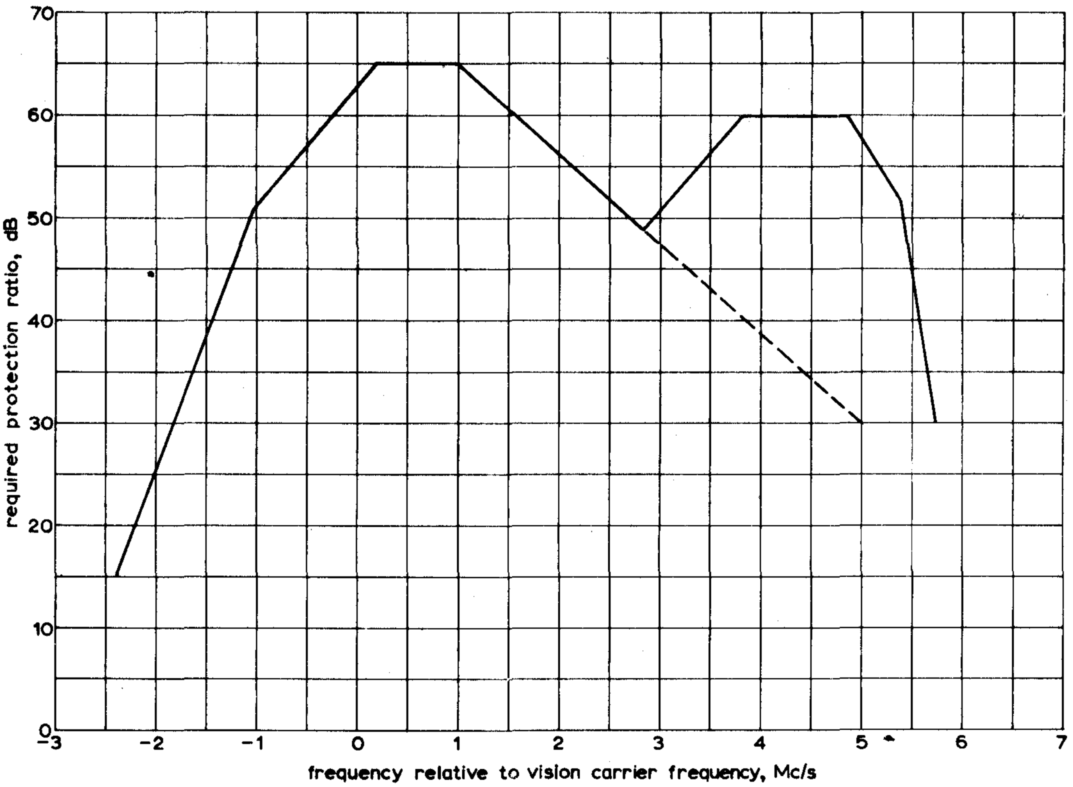

Fig. 8 - Protection ratios required by a 625-line system from a c.w. interfering signal

——— NTSC colour television system ------ Monochrome television system

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U.H.F. HARMONIC RADIATION FROM V.H.F. TUNERS IN TELEVISION RECEIVERS

Technological Report No. T-124

(1964/15)

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March 1964

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U.H.F. HARMONIC RADIATION FROM V.H.F. TUNERS IN TELEVISION RECEIVERS

SUMMARY

The local oscillator of a v.h.f. television receiver tends to radiate energy at harmonics of the fundamental oscillator frequency. Some of these harmonics fall within the u.h.f. Bands IV and V and may, therefore, interfere with the reception of u.h.f. television transmissions.

The radiation of oscillator harmonics of several v.h.f. television receivers has been measured, and the results obtained show that radiation at the lower harmonics of the fundamental oscillator frequency when tuned to signals in Bands I and III can cause interference, particularly if an indoor u.h.f. aerial is used in proximity to a v.h.f. receiver. It is possible that interference with the reception of u.h.f. television transmissions will occur due to the direct radiation of oscillator harmonics from the aerial of a v.h.f. receiver. This aspect of the problem is not, however, considered in this report.

1. INTRODUCTION

The introduction of television transmissions at ultra-high frequencies (u.h.f.) in Bands IV and V in the United Kingdom necessitates an investigation of the radiation of unwanted signals from the local oscillators of domestic television receivers tuned to signals in Bands I and III. These unwanted signals may interfere with the reception of u.h.f. transmissions.

The interference with u.h.f. reception can occur due to the radiation of very-high frequency (v.h.f.) oscillator harmonics from the v.h.f. receiving aerial, or to direct radiation from the circuits of the v.h.f. receiver. In this report only the latter aspect of the problem is discussed.

Bands I and III contain thirteen channels which are used for television broadcasting, and all these channels have v.h.f. local-oscillator harmonic frequencies that fall within Bands IV and V. It would not, however, be practicable to investigate radiation at all these frequencies, and the investigation has been limited to a consideration of radiation at the third harmonic of the local-oscillator frequency used when receiving Channel 9, and the seventh harmonic of the local-oscillator frequency used when receiving Channel 1. Fig. 1 shows how harmonics generated by the local oscillators of receivers tuned to Channel 1 and Channel 9 can cause interference with reception in Bands IV and V.

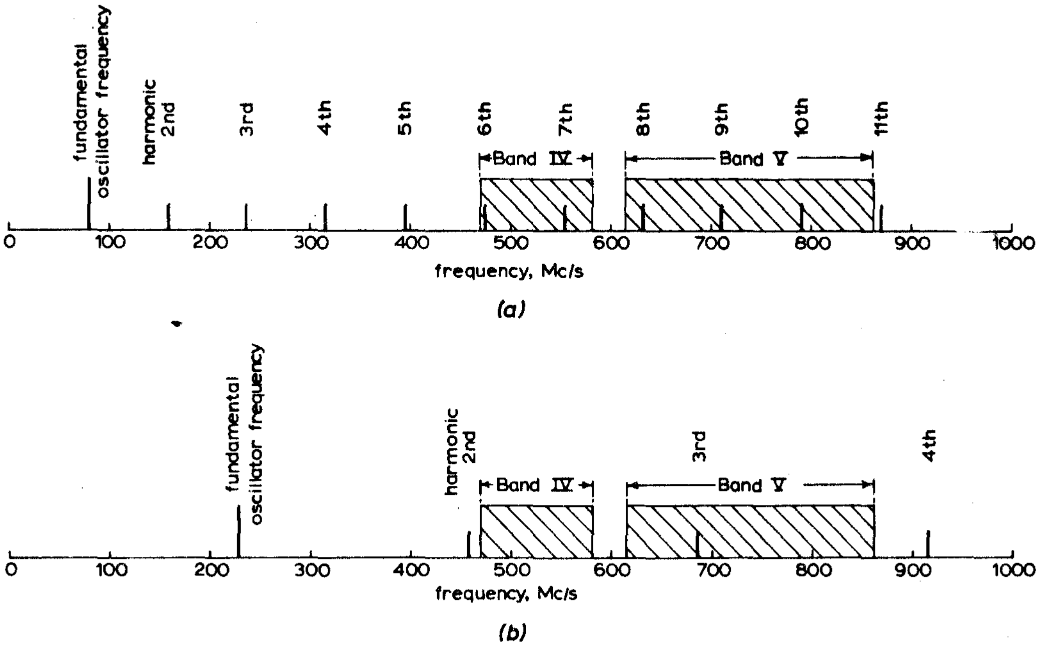

Fig. 1 - V.H.F. oscillator harmonic frequencies in relation to Bands IV and V

(a) Channel 1 local oscillator harmonics
(b) Channel 9 local oscillator harmonics

2. EXPERIMENTAL PROCEDURE

Radiation of oscillator harmonics from v.h.f. receivers will mainly affect u.h.f. receivers situated in adjacent rooms of semi-detached houses, terraced houses and flats. The radiation picked up by a horizontally-polarized u.h.f. aerial may, therefore, arrive from any direction and at any angle to the vertical; the complete radiation pattern of the v.h.f. 'interfering' receiver* is therefore of interest. In order to assess the complete radiation pattern, the interfering receiver was rotated round the three mutually perpendicular axes shown in Fig. 2, and the radiation measured using a directional u.h.f. Yagi array† and a suitable detector.

If axis (a) in Fig. 2 (for which the receiver is upright) is taken as the reference, then for rotation about axes (b) and (c), the receiver is stood on its side and placed face down respectively. The u.h.f. receiving aerial will, in the great majority of cases, be horizontally polarized in practice and thus for rotation about axis (a), (in which the radiation pattern in the horizontal plane is measured) the Yagi aerial was arranged to be horizontally polarized. When the u.h.f. aerial is not in the horizontal plane of the interfering receiver, it may, depending on its orientation, receive both the vertically and horizontally polarized components of radiation. Thus for rotation about axes (b) and (c), measurements were made with the Yagi aerial polarized both horizontally and vertically. In each case the two

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* For convenience, the v.h.f. receiver causing interference is referred to as an 'interfering' receiver. The u.h.f. receiver which suffers interference is referred to simply as the u.h.f. receiver.

† This array had two directors and a wire mesh reflector and had a gain of 8 dB relative to a half-wave dipole.

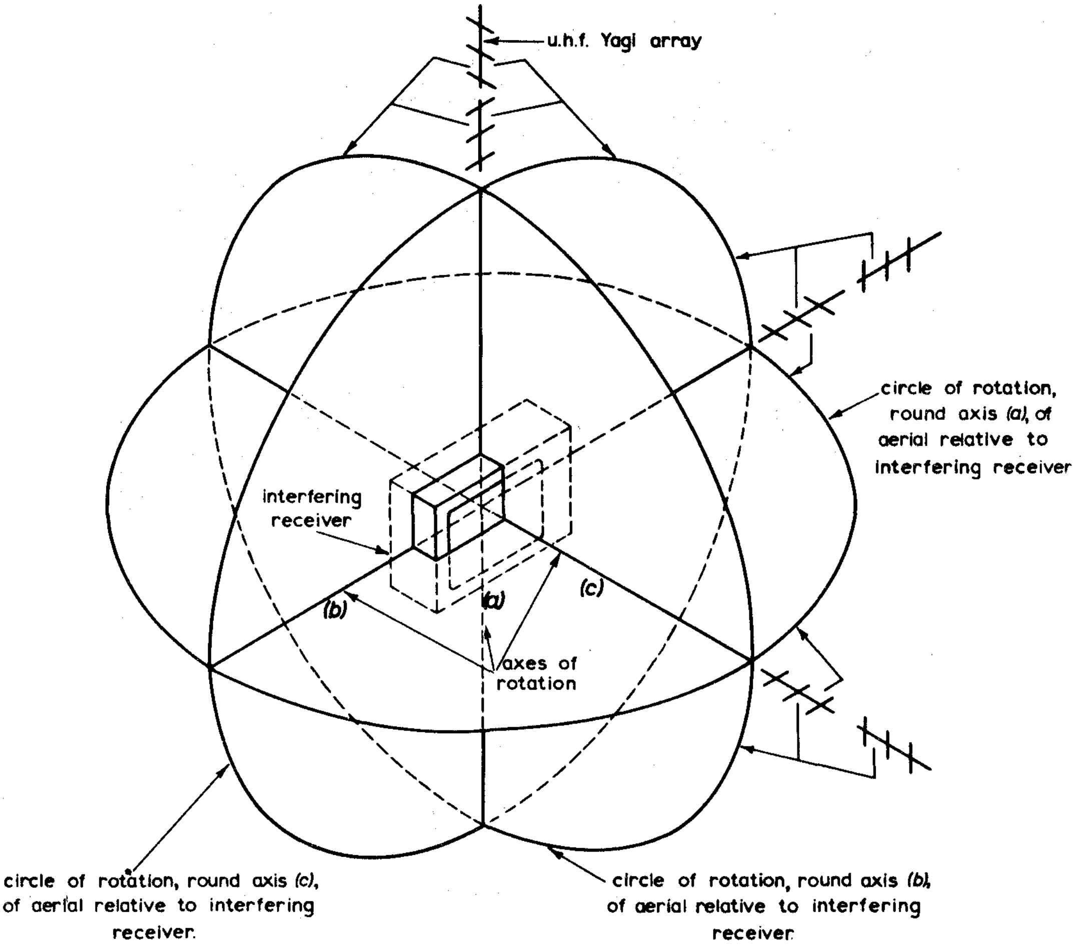

u.h.f. Yagi array
circle of rotation, round axis (a), of aerial relative to interfering receiver
interfering receiver
(b)
(a)
(c)
axes of rotation
circle of rotation, round axis (c), of aerial relative to interfering receiver.
circle of rotation, round axis (b), of aerial relative to interfering receiver.

Fig. 2 - Axes of rotation around which the u.h.f. aerial was moved relative to the interfering receiver

sets of results obtained were combined to give the resultant field strength, and a table to simplify this process is given in the Appendix.

The measurements of radiation were made in a large room approximately 60 feet (18 metres) long by 30 feet (9 metres) wide by 25 feet (7·5 metres) high, and the aerial was situated sufficiently near the receiver under test (the distance between the receiver and aerial was 9 feet (2·73 metres)) for the effects of any underfloor cables and other metallic reflectors on the radiation pattern of the interfering receivers to be negligible. As a check that the measurements were not influenced by the proximity of pipes and other metal objects, measurements on one interfering receiver were made both out-of-doors and in the large room. The two sets of results obtained were modified to correspond to a distance of 10 metres between the u.h.f. aerial and the interfering receiver, and are plotted in Fig. 3. The angle α between the interfering receiver and the u.h.f. aerial was 90° when the aerial was pointing directly at the front of the receiver for axes (a) and (b) or at the top of the receiver for axis (c). In addition, α was assumed to increase as the receiver was turned in a clockwise direction. The average difference between the two sets of results is 0·25 dB; it was therefore felt that negligible errors were introduced when measurements were carried out in the large room.

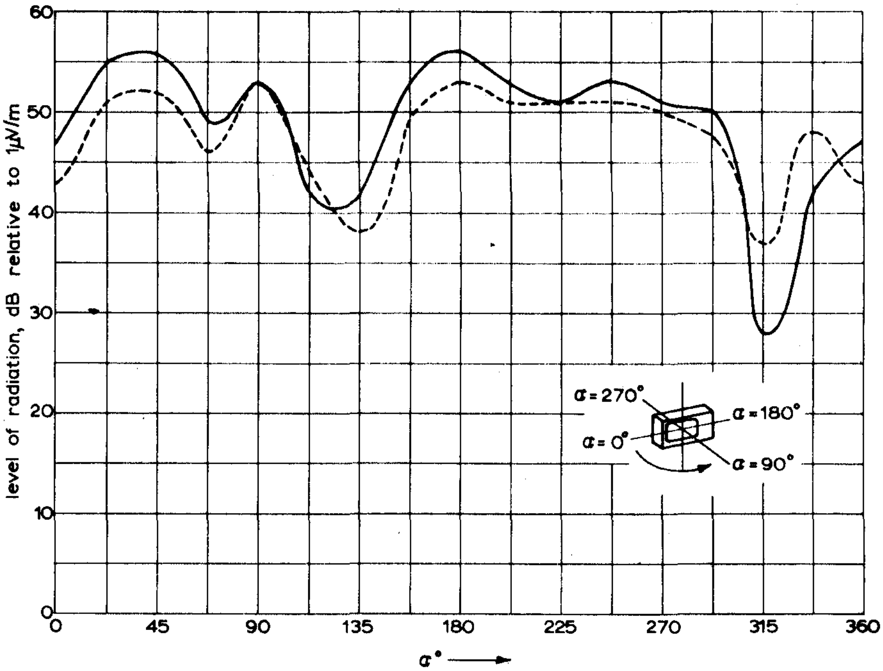


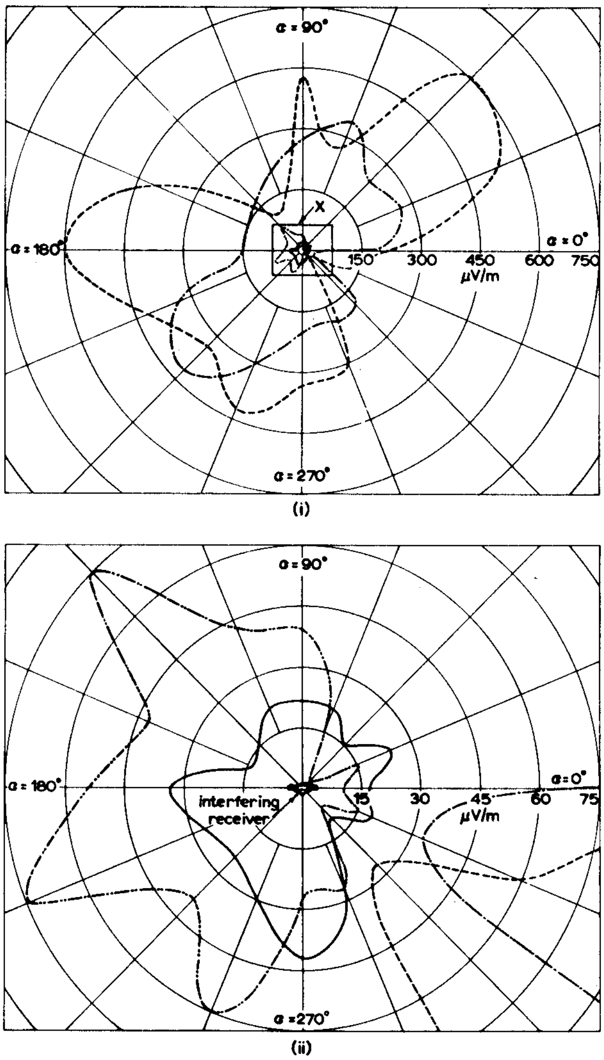
Fig. 3 - Comparison of results obtained with the interfering receiver out-of-doors and in a large room

——— Results obtained in large room
- - - - - Results obtained out-of-doors

The measurements of radiation were made by tuning a communications receiver to the appropriate frequency, and measuring the field strength by comparing the u.h.f. aerial output with a signal of known amplitude from a signal generator. The results were in the form of voltages at the receiver input terminals expressed in decibels relative to one microvolt. From these voltages and the known effective gain of the u.h.f. aerial, the field strength in μV/m was obtained and standardized to give the radiated field strength at a distance of 10 metres from the receiver. The radiation patterns of four different makes of domestic receiver were measured at the third harmonic of the local-oscillator frequency used for Channel 9. The receivers were of the dual-standard 405/625-line type, and are thus typical of the v.h.f. receivers likely to come into use when the u.h.f. television service is implemented. Each receiver was rotated through 360° in steps of 22·5° about each of the three mutually perpendicular axes described. The results obtained are plotted in Figs. 4, 5 and 6, which show comparative measurements made on the four receivers about each of the three axes.

3. DISCUSSION OF RESULTS

The detailed measurements shown in Figs. 4, 5 and 6 were made only for the third harmonic of the Channel 9 local-oscillator frequency, since in this case, the interfering harmonics are of a lower order than for Band I, and are thus likely to result in a greater interfering field strength. As a check, however, measurements were also made using the seventh harmonic of the local-oscillator signal corresponding to Channel 1 for one receiver rotated about axis (a). Fig. 7 shows a comparison of



(i) Complete radiation patterns

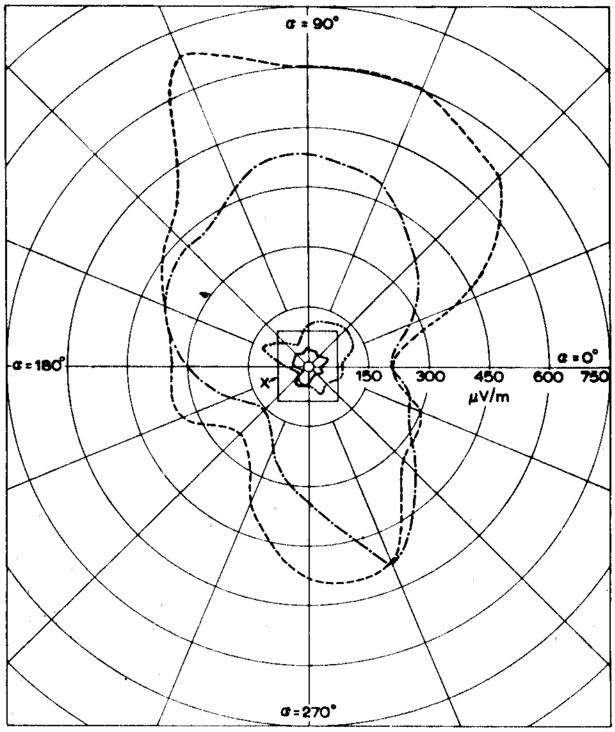
(ii) Magnified section of radiation patterns within area X in Fig. 4(i).

Fig. 4 - Radiation patterns of third harmonic signal of Channel 9 local oscillator for rotation about axis (a)

——— Receiver A
------ Receiver B
—-—- Receiver C
—··— Receiver D

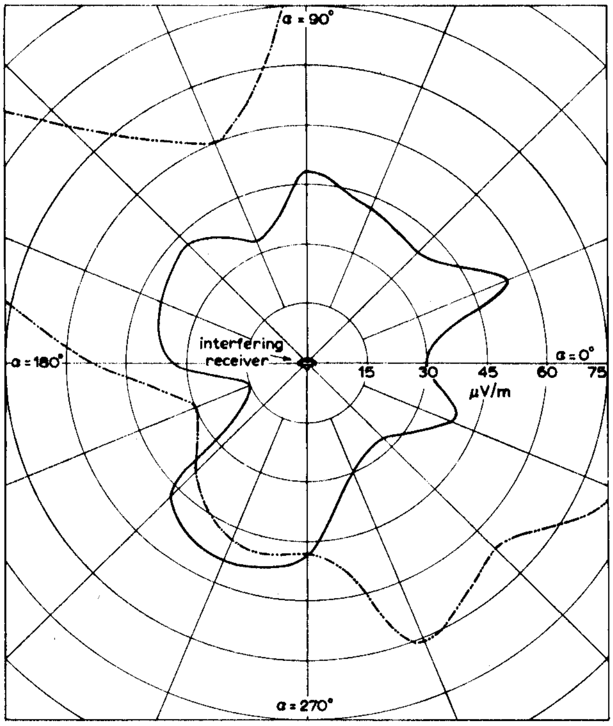
these results with those obtained for the Channel 9, third-harmonic case. It is apparent from this figure that in a given band, the oscillator harmonics of a Band III interfering receiver are of much greater amplitude than those of a Band I receiver; the restriction of detailed measurements to the radiation of receivers switched to Band III is therefore justified.

It has been found[1] that a protection ratio of about 50 dB (reference 1 μV/m) is required for a 625-line system when a c.w. interfering signal is present at the vision-carrier frequency of the 625-line system. This protection ratio relates to the interference being definitely perceptible, and applies to both monochrome and NTSC colour systems. For the interference to be only just perceptible, however, a further 15 dB of protection[1] is required. Under conditions of fringe area reception,



(i)

(i) Complete radiation patterns



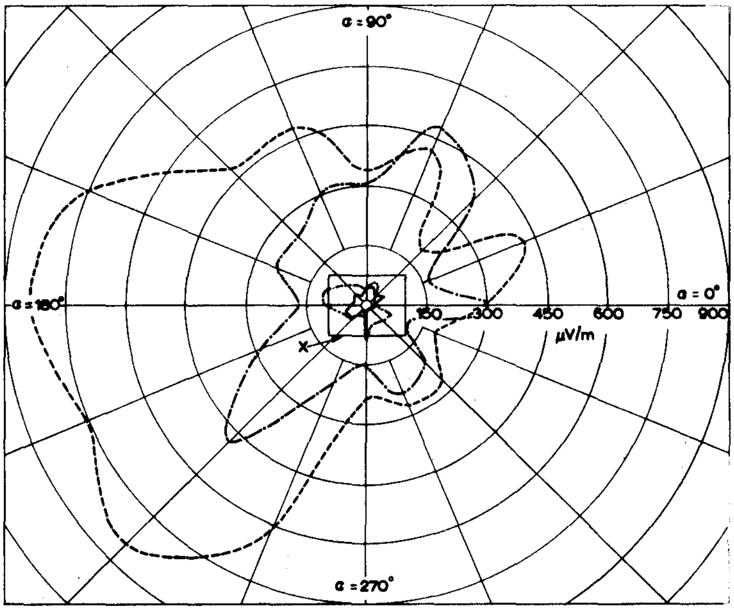
(ii)

(ii) Magnified section of radiation patterns within area X in Fig. 5(i).

Fig. 5 - Radiation patterns of third harmonic signal of Channel 9 local oscillator for rotation about axis (b)

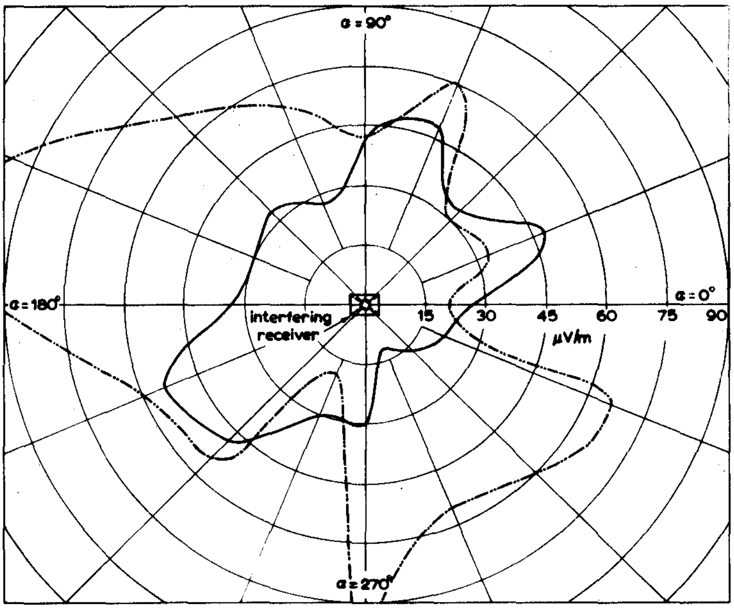
—— Receiver A	----- Receiver B
–·–·– Receiver C	—–— Receiver D

(i) Complete radiation patterns



(i)

(ii) Magnified section of radiation patterns within area X in Fig. 6(i).



(ii)

Fig. 6 - Radiation patterns of third harmonic signal of Channel 9 local oscillator for rotation about axis (c)

—— Receiver A
------ Receiver B
—·—·— Receiver C
——·—— Receiver D

therefore, when the wanted field strength is 65 dB above 1 μV/m,[2] an interfering field strength of 0 dB (1 μV/m) would be acceptable if no discrimination were provided by the directivity of the u.h.f. receiving aerial. In practice, however, it is improbable that the u.h.f. receiving aerial would be pointing directly at the v.h.f. receiver and a discrimination of 15 dB is assumed against the interfering field for this reason. In addition, there will normally be at least one wall and roof interposed

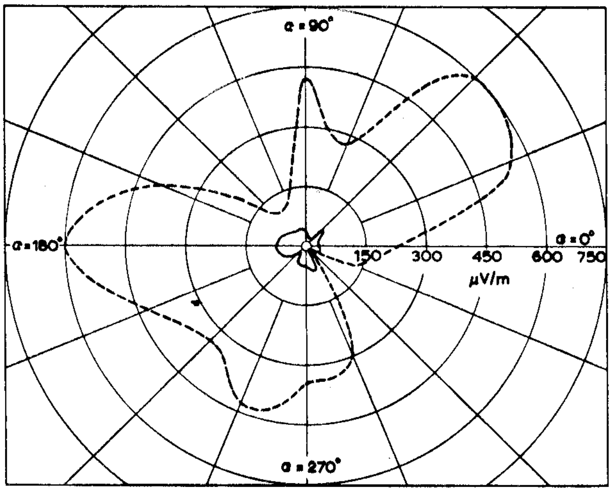


Fig. 7
Comparison of radiation pattern of third harmonic signal of Channel 9 local oscillator with radiation pattern of seventh harmonic signal of Channel 1 local oscillator for receiver B

----- 3rd harmonic radiation pattern
—— 7th harmonic radiation pattern

between the u.h.f. aerial and the interfering receiver and this will add significantly to the attenuation of the interfering field by an amount estimated to be about 15 dB. Taking these factors into account, it is thought that a realistic figure for the permissible field strength of a radiated harmonic at a distance of 10 metres from an interfering v.h.f. television receiver in a fringe area of reception would be 30 dB (32 μV/m). It is presumed that most u.h.f. domestic installations will use external receiving aerials situated 30 feet (9 metres) or more from the interfering v.h.f. receiver, and will be operating in areas of average reception. In this case, Figs. 4, 5 and 6 show that the degree of interference from two of the receiver local oscillators is likely to be small. In the case of the other two receivers, however, very considerable interference may be caused under these conditions.

Indoor u.h.f. aerials may be used in areas of good reception where the wanted u.h.f. field strength will be at least 80 dB above 1 μV/m.[2] In this case, making allowance for the low directivity of such aerials, a radiated-harmonic field strength of the order of 35 dB (56 μV/m) would be acceptable. However, with this type of u.h.f. receiving aerial, the distance between the v.h.f. interfering receiver and the u.h.f. aerial might be as little as 3 feet (less than 1 metre); for example, if the receivers were situated back-to-back against the party wall of two semi-detached homes. Under such circumstances, objectionable interference could be caused by all of the v.h.f. receivers tested.

In considering the cases of u.h.f. reception with both indoor and outdoor aerials, it should be remembered that the figures for permissible interfering field strength quoted in this report assume that the interfering harmonic has the same frequency as the wanted vision carrier. The relationship between the required protection ratio for a 625-line system from a c.w. interfering signal and the frequency difference between the vision carrier of the wanted signal and the interfering signal is shown in Fig. 8.[1] It is seen that the required protection ratio decreases with offset of the interfering signal frequency from the wanted vision carrier frequency, particularly for a monochrome system. In the fringe area of reception considered, there will be no possibility of interference if this offset is outside the range -1·25 Mc/s to +3·25 Mc/s for monochrome reception or -1·25 Mc/s to +5·~~7~~5 Mc/s for +5·5 colour reception, since the greatest field strength of radiated harmonic measured was 49 dB (282 μV/m) at a distance of 10 metres from the interfering receiver, and the required protection ratio outside these frequency offset ranges is less than 46 dB.

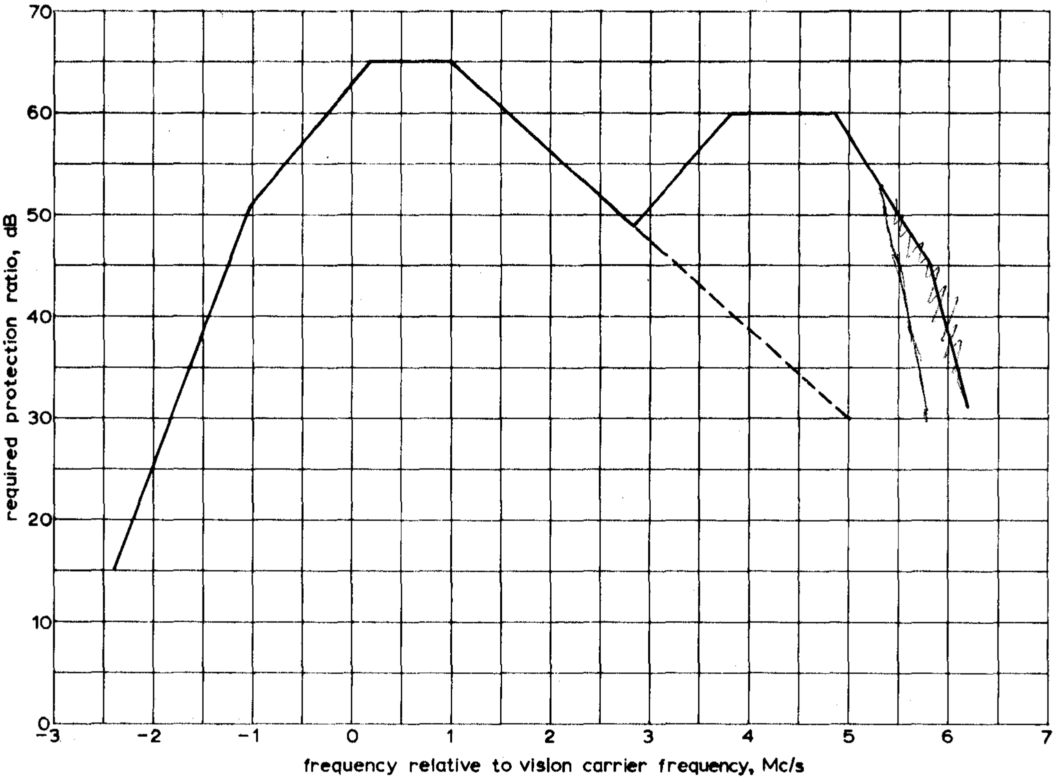


Fig. 8 - Protection ratios required by a 625-line system from a c.w. interfering signal

——— NTSC colour television system ----- Monochrome television system

When an indoor u.h.f. aerial is used in an area of good reception, however, interference may still be caused, irrespective of offset between the wanted signal vision carrier and the nearest interfering harmonic, provided, of course, that the interfering harmonic falls within the passband of the u.h.f. receiver when tuned to the local u.h.f. television transmissions.

4. CONCLUSIONS

The experiments described show that there is considerable risk of interference in the u.h.f. bands if a low-order harmonic of a v.h.f. local oscillator falls within the passband of a u.h.f. receiver. The risk of interference to u.h.f. installations using indoor aerials is even greater and the use of such aerials should be discouraged wherever possible.

It should be noted that these conclusions refer only to interference to domestic u.h.f. receiving installations caused by direct radiation of v.h.f.-oscillator harmonics from the circuits of v.h.f. television receivers.

5. REFERENCES

1. 'Technical Data Used by the European V.H.F./U.H.F. Broadcasting Conference', Stockholm, 1961. (International Telecommunication Union.)
2. 'Television Field Trials of 405-Line and 625-Line Systems in the U.H.F. and V.H.F. Bands, 1957/58', BBC Report, May 1960.

APPENDIX

In this Appendix a table is given which simplifies the process of finding the resultant of two orthogonal vectors when the magnitudes of each are given in decibels relative to the same reference level.

The two vectors are denoted by **A** and **B**, and their magnitudes by A and B. It is assumed that $A > B$. If the magnitudes of **A** and **B** when given in decibels are A' and B', the magnitude of their resultant is given by:

$$R = A' + f(A, B)$$

where R is also in decibels and $f(A, B)$ is a correction factor which may be obtained from the table:

$$f(A, B) = 10 \log_{10} [1 + (B/A)^2] \text{ dB}$$

decibels	
$(A' - B')$	$f(A, B)$
0	3·01
1	2·54
2	2·12
3	1·76
4	1·45
5	1·19
6	0·97
7	0·79
8	0·64
9	0·51
10	0·41

decibels	
$(A' - B')$	$f(A, B)$
11	0·32
12	0·26
13	0·21
14	0·17
15	0·14
16	0·10
17	0·08
18	0·06
19	0·05
20	0·04

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